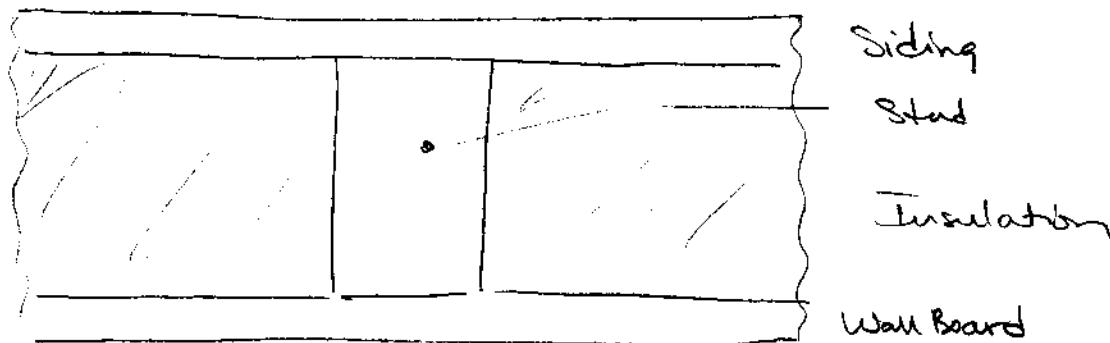


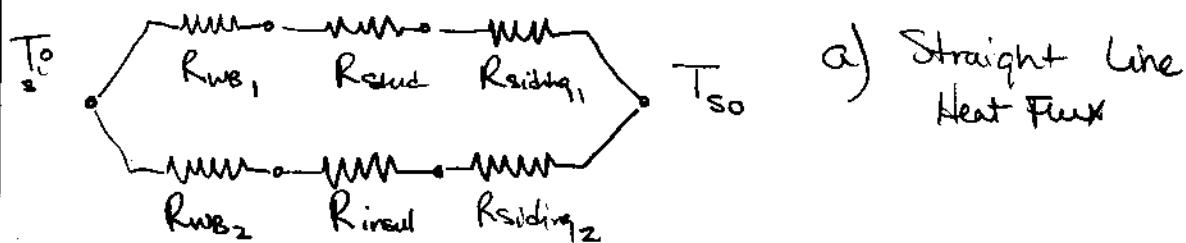
Problem 3.15

Composite Wall

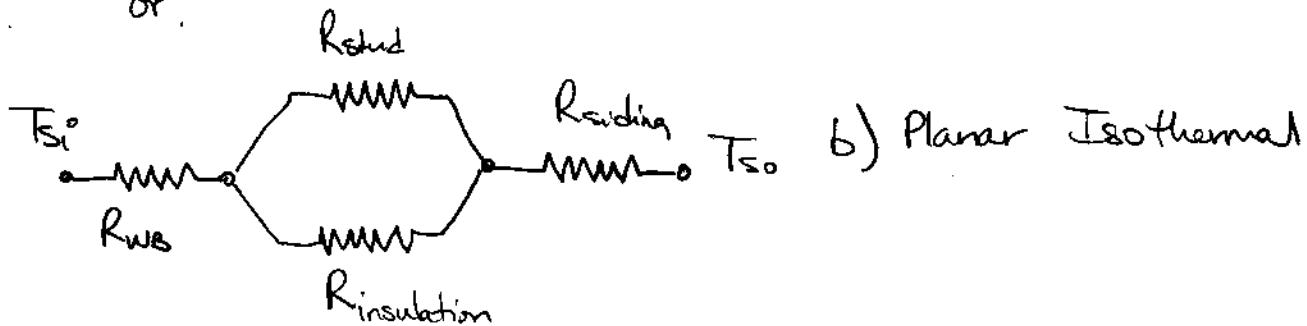


Find Thermal Resistance of Wall
that is $2.5\text{m} \times 6.5\text{m}$ w/ 10 studs

Choice of Circuits



or.



using circuit A

$$k_{\text{siding}} = 0.094 \text{ W/mK}$$

$$L_{\text{siding}} = 0.008 \text{ m}$$

$$k_{\text{stud}} = 0.12 \text{ W/mK}$$

$$L_{\text{stud}} = 0.13 \text{ m}$$

$$A_1 = A_{\text{stud}} = 10 \times 0.04 \text{ m} \times 2.5 \text{ m}$$

$$A_2 = A_{\text{insulation}} = 2.5 \text{ m} \times 6.5 \text{ m} - A_1$$

$$A_1 = 1 \text{ m}^2$$

$$A_2 = 15.25 \text{ m}^2$$

$$K_{insulation} = 0.038 \text{ W/mK}$$

$$L_{insulation} = 0.13 \text{ m}$$

$$K_{WB} = 0.17 \text{ W/mK}$$

$$L_{WB} = 0.012 \text{ m}$$

$$R_{stud} = \frac{L_{WB}}{K_{WB} A_1} + \frac{L_{stud}}{K_{stud} A_1} + \frac{L_{siding}}{K_{siding} A_1}$$

$$R_{stud} = 1.239 \text{ K/W}$$

$$R_{ins} = \frac{L_{WB}}{K_{WB} A_2} + \frac{L_{ins}}{K_{ins} A_2} + \frac{L_{siding}}{K_{siding} A_2}$$

$$R_{ins} = 0.2345 \text{ K/W}$$

$$R_{TOT} = \left[\frac{1}{R_{stud}} + \frac{1}{R_{ins}} \right]^{-1} = 0.1972 \text{ K/W}$$

using circuit B

$$R_{WB} = \frac{L_{WB}}{K_{WB} A_{TOT}} = 0.00434 \text{ K/W}$$

$$R_{stud} = \frac{L_{stud}}{K_{stud} A_1} = 1.08$$

$$R_{ins} = \frac{L_{ins}}{K_{ins} A_2} = 0.2243$$

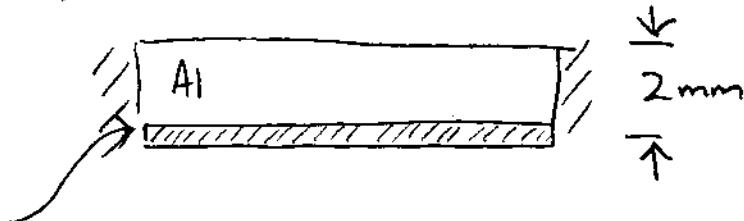
$$R_{siding} = \frac{L_{siding}}{K_{siding} A_1} = 0.005$$

$$R_{TOT} = R_{WB} + \left[\frac{1}{R_{stud}} + \frac{1}{R_{ins}} \right]^{-1} + R_{siding}$$

$$R_{TOT} = 0.1953 \text{ K/W}$$

Problem 3.26 Silicon Chip

$$\rightarrow T_{\infty} = 25^{\circ}\text{C} \quad h = 1000 \frac{\text{W}}{\text{m}^2 \text{K}}$$



$$R_c'' = 0.5 \times 10^{-4} \frac{\text{m}^2 \text{K}}{\text{W}} \quad A = 100 \text{ mm}^2$$

$$T_{\max, \text{chip}} = 85^{\circ}\text{C}$$

Find maximum power dissipation (\dot{q})

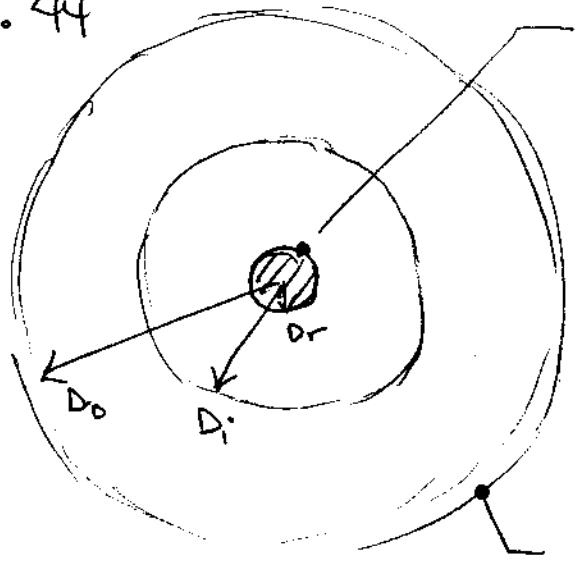
$$T_{\text{chip}} - R''_{\text{contact}} - R''_{\text{AL}} - R''_{\text{conv}} = T_{\infty} \quad K_{\text{AL}} = 237 \frac{\text{W}}{\text{mK}}$$

$$R''_{\text{tot}} = R''_c + \frac{L}{K_{\text{AL}}} + \frac{1}{h} = 1.0584 \times 10^{-3} \frac{\text{m}^2 \text{K}}{\text{W}}$$

$$\dot{q}'' = \frac{\Delta T}{R''_{\text{tot}}} = \frac{85^{\circ}\text{C} - 25^{\circ}\text{C}}{R''_{\text{tot}}} = 56687 \frac{\text{W}}{\text{m}^2}$$

$$\boxed{\dot{q} = \dot{q}'' \cdot A = 5.67 \text{ W}}$$

Problem 3.44



$$\dot{q}^o = 2 \times 10^6 \text{ W/m}^3$$

$$D_r = 20 \text{ mm}$$

Ceramic

$$D_i = 40 \text{ mm}$$

$$D_o = 120 \text{ mm}$$

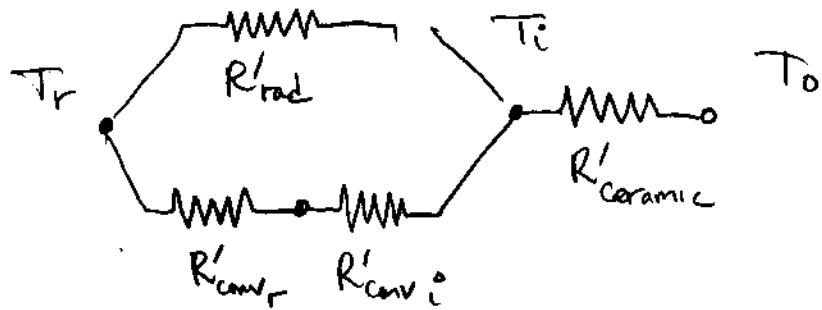
$$k = 1.75 \text{ W/mK}$$

$$R'_{rad} = 0.30 \frac{\text{mK}}{\text{W}}$$

$$h_{\text{free, enclosure}} = 20 \text{ W/m}^2\text{K}$$

$$q' = \dot{q}^o \cdot \frac{\pi D_r^2}{4}$$

$$q' = 628.3 \text{ W/m}$$



$$R'_{conv,r} = \frac{1}{\pi D_r h} = 0.796 \frac{\text{mK}}{\text{W}}$$

$$R'_{conv,i} = \frac{1}{\pi D_i h} = 0.3979 \frac{\text{mK}}{\text{W}}$$

$$R'_{ceramic} = \frac{\ln(D_o/D_i)}{2\pi k} = 0.10 \frac{\text{mK}}{\text{W}}$$

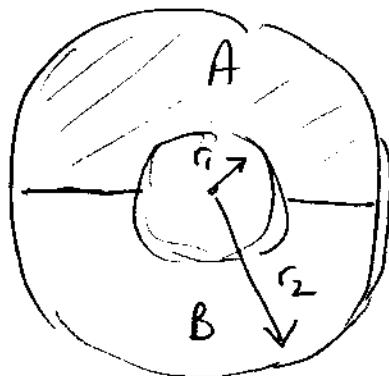
$$R'_{tot} = R'_{ceramic} + \left[\frac{1}{R'_{conv,r} + R'_{conv,i}} + \frac{1}{R'_{rad}} \right]^{-1} = 0.34$$

$$\Delta T = q' \cdot R'_{tot} = 213.5 \Rightarrow T_r = 238.5^\circ\text{C}$$

Problem 3.52 Steam Pipe

$$r_1 = 50 \text{ mm}$$

$$r_2 = 100 \text{ mm}$$



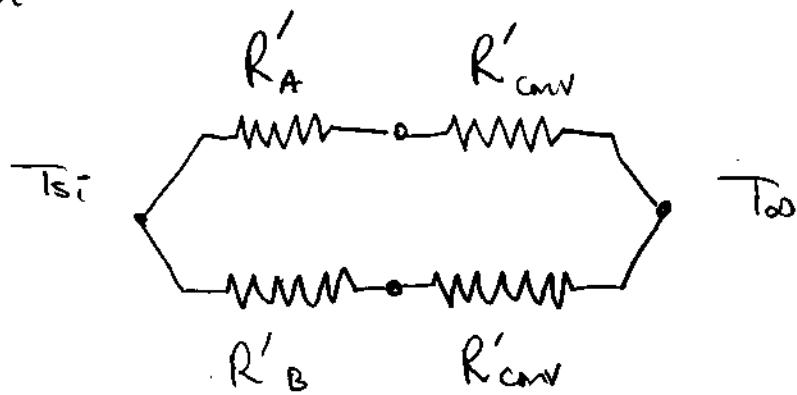
$$K_A = 2 \text{ W/mK}$$

$$K_B = 0.25 \text{ W/mK}$$

$$T_{si} = 500 \text{ K}$$

$$T_{oo} = 300 \text{ K}$$

$$h = 25 \text{ W/m}^2\text{K}$$



Find q

\downarrow (only half pipe - twice resistance)

$$R'_A = 2 \frac{\ln \frac{r_2}{r_1}}{2\pi K_A} = 0.1103 \frac{\text{mK}}{\text{W}}$$

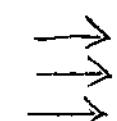
$$R'_{conv} = 2 \frac{1}{\pi D_2 h} = 0.1273 \frac{\text{mK}}{\text{W}}$$

$$R'_B = 2 \frac{\ln \frac{r_2}{r_1}}{2\pi K_B} = 0.8825 \frac{\text{mK}}{\text{W}}$$

$$R'_{TOT} = \left[\frac{1}{R'_A + R'_{conv}} + \frac{1}{R'_B + R'_{conv}} \right]^{-1} = 0.1923 \frac{\text{mK}}{\text{W}}$$

$$q' = \frac{\Delta T}{R'} = 1040 \text{ W/m}$$

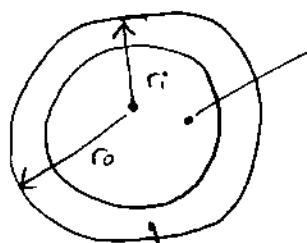
Problem 3.95 Radioactive Wastes



Water

$$T_{\infty} = 25^{\circ}\text{C}$$

$$h = 1000 \text{ W/m}^2\text{K}$$



Radioactive Wastes

$$k_{rw} = 20 \text{ W/mK}$$

$$\dot{q} = 10^5 \text{ W/m}^3$$

Stainless Steel

$$k_{ss} = 15 \text{ W/mK}$$

$$r_o = 0.5 \text{ m}$$

$$r_o = 0.6 \text{ m}$$

a) Find $T_{s,0}$

$$\dot{q} = \dot{q} \cdot V = \dot{q} \cdot \frac{4}{3} \pi r_o^3$$

$$\dot{q} = 52360 \text{ W}$$

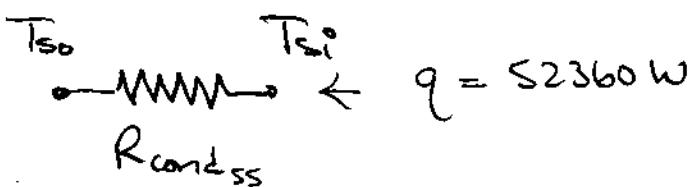
$$\dot{q} = h A_s [T_{s,0} - T_{\infty}]$$

$$T_{s,0} = 36.57^{\circ}\text{C}$$

$$A_s = 4\pi r_o^2 = 4.524 \text{ m}^2$$

$$h = 1000 \text{ W/m}^2\text{K}$$

b) Find $T_{s,i}$



$$R_{cond_{ss}} = \frac{1/r_i - 1/r_o}{4\pi k_{ss}} = 0.001768 \frac{\text{K}}{\text{W}}$$

$$\Delta T = \dot{q} \cdot R = 92.6^{\circ}\text{C}$$

$$T_{s,i} = 129.17^{\circ}\text{C}$$

c) Obtain an expression for $T(r)$ inside the sphere

$$\frac{1}{r^2} \frac{d}{dr} \left(K_r^2 \frac{dT}{dr} \right) = -\dot{q}^\circ \quad \leftarrow \begin{array}{l} \text{Eq 2.23} \\ \text{reduces} \\ \text{1D, steady state} \end{array}$$

$$\frac{d}{dr} \left(K_r^2 \frac{dT}{dr} \right) = -\dot{q}^\circ r^2$$

$$K_r^2 \frac{dT}{dr} = -\dot{q}^\circ \frac{r^3}{3} + C_1$$

$$\frac{dT}{dr} = -\frac{\dot{q}^\circ}{K_r} \frac{r}{3} + \frac{C_1}{r^2}$$

$$T(r) = -\frac{\dot{q}^\circ r^2}{6K_r} + \frac{C_1}{r} + C_2$$

Hottest point is at Center

$$\left. \frac{dT}{dr} \right|_{r=0} = 0 \Rightarrow C_1 = 0$$

$$T(r_i) = T_{Si} = -\frac{\dot{q}^\circ r_i^2}{6K_r} + C_2$$

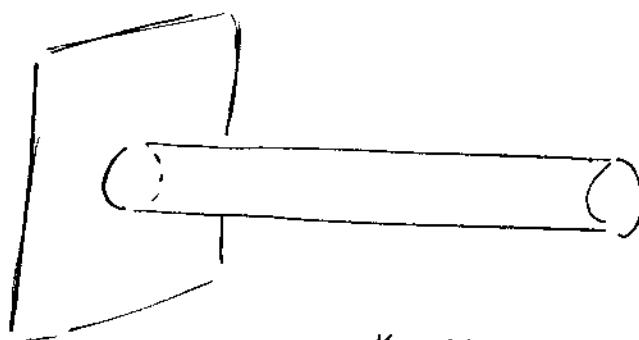
$$C_2 = T_{Si} + \frac{\dot{q}^\circ r_i^2}{6K_r}$$

$$T(r) = \frac{\dot{q}^\circ}{6K_r} (r_i^2 - r^2) + T_{Si}$$

$$T(0) = \frac{\dot{q}^\circ r_i^2}{6K_r} + T_{Si} = 208.3 + 129.2$$

$$\boxed{T(0) = 337.5^\circ C}$$

Problem 3.119 Long, circular aluminum rod



* assume infinite fin

$$q = \sqrt{hPKA_c} \theta_b$$

a) Tripled Diameter

$$\frac{q_{3D}}{q_0} = \frac{\sqrt{h\pi(3D)K\pi(3D)^2} \theta_b}{\sqrt{h\pi D K\pi D^2} \theta_b} = 3^{3/2} = 5.2$$

Times greater

$$\frac{q_{Cu}}{q_{Al}} = \frac{\sqrt{hPKA_c} \theta_b}{\sqrt{hPKA_c} \theta_b} = \sqrt{\frac{K_{Cu}}{K_{Al}}}$$

$$\frac{q_{Cu}}{q_{Al}} = \sqrt{\frac{401}{237}} = 1.3$$

times greater